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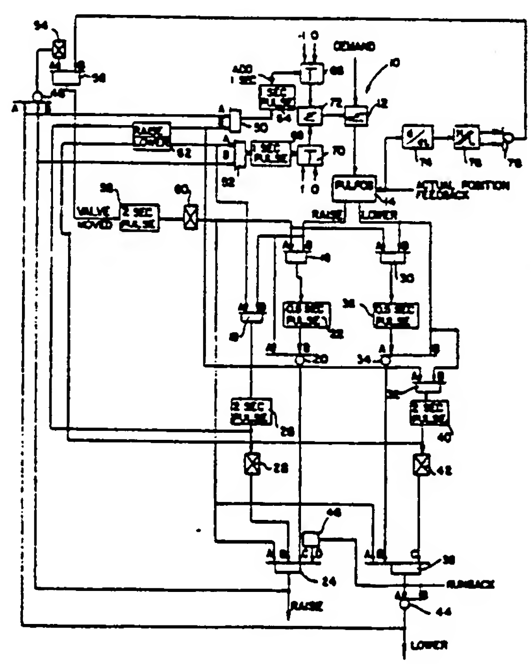
(54) Control of positioning devices.

(57) A controller, for close positioning or modulating control of an electric motor, includes means (14) for comparing a signal (DEMAND) representative of the demand on a system with a signal (ACTUAL POSITION FEEDBACK) representative of the actual position of the motor or a valve associated therewith. If the difference between the signals exceeds a "deadband" and no action has been taken within a first time interval, and if the last movement of the valve was in the same direction and a second time interval has elapsed, a motor run pulse (RAISE, LOWER) is generated. If the last movement of the valve was in a direction opposite to that desired, the motor run pulse is extended to overcome "backlash" resulting from the reversal of motor rotation.



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CONTROL OF POSITIONING DEVICES

This invention relates to control systems for close positioning or modulating control of positioning devices, for example electric motors.

Typically, close positioning or modulating control of electric motors requires the use of special start/stop or jogging equipment. In addition, because of the higher duty cycle, a non standard motor having a higher temperature rating is usually required. Each attempt to start the motor generates heat within the motor, and repeated attempts will result in overheating and destruction of the motor if a standard motor is used. The use of such a non-standard motor having a high insulation temperature rating significantly increases the overall cost of the system.

Most close positioning or modulating control systems also use a gear reducer on the output of the electric motor. Due to the inertia of the motor and gear reducer, the desired new position of the motor is "overshot", and the motor needs to be reversed in order to assume the proper position. Motor reversal may also be due to the need to establish a new p[osition. This reversal requires a disproportionate motor movement due to gearing "backlash". Repeated energisation or jogging to provide the fine tuning of the position also contributes to overheating and destruction of the motor. Thus, the use of a non-standard motor in presently available close positioning or modulating control systems is imperative.

According to the present invention there is provided a control system for close positioning or modulating control of a positioning device, the system comprising comparing means for comparing the actual position of the positioning device with a desired position of the positioning device, the comparing means being operative to produce an output signal when the actual position of the positioning device differs from the desired position of the positioning device by more than a predetermined value, and means responsive to the output signal produced by the comparing means, said output signal responsive means being operative to cause the positioning device to move towards the desired position if a first predetermined period of time has elapsed since the last movement of the positioning device and if a second predetermined period of time has elapsed if the last movement of the positioning device was in a direction opposite to that of the desired position of the positioning device.

A preferred embodiment of the invention described in detail hereinbelow provides a controller (control system) for close positioning or modulating control of a motor which can be used with a motor having a standard insulation temperature rating without the possibility of overheating the motor during repeated close positioning of the motor. The preferred controller comprises logic circuitry to provide the features desired. The controller compares a signal representative of the demand on the system with a signal representative of the actual position of the motor or a valve associated therewith and, if the foregoing signals are within an adjustable "deadband", no action is taken. If, however, the difference between these signals exceeds the adjustable "deadband" and no action has been taken within a previous time interval, a motor run pulse having a duration proportional to the foregoing difference is produced. If action had been taken during the previous time interval, a motor run pulse is not produced until the expiration of a determined period of time. If the motor or valve had last moved in a direction opposite to the direction of the new motor run pulse, a predetermined period of time is added to the new motor run pulse to compensate for gearing "backlash" which will occur during the reversal of motor rotation. If the new motor run pulse results in running the motor in the same direction, the motor run pulse will be outputted without modification. If the motor is already in operation and the new motor run pulse results in continued running in the same direction, the motor run pulse will be extended for the newly computed duration. However, if the new motor run pulse results in operating the motor in the opposite direction, the existing motor run pulse is immediately terminated to minimise overshooting of the required position, and a predetermined period of time must elapse before the new motor run pulse is applied to the system. Through the use of the "deadband" concept, variable duration run puls and the introduction of predetermined periods of time before certain motor run pulses are allowed to be generated, overheating of the motor is minimised and a standard electric motor can be used.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawing, the single figure of which is a schematic diagram of a system for controlling a motor or other positioning device.

The drawing shows a system 10 for controlling a motor or other positioning device. The system 10 compares the actual position of a motor, or a valve associated with a motor, with a desired position thereof and, if the foregoing positions are within an adjustable "deadband", no action is taken. If, however, the foregoing positions exceed the "deadband", a motor control pulse if continuously produced until the foregoing positions are within the desired "deadband".

A signal representative of a demand on the system 10 is applied to an input of a summation function generator 12 which has an output connected to an input of a pulse position function generator 14. A signal representative of the actual position of the valve (feedback signal) is applied to another input of the pulse position function generator 14. The pulse position function generator 14 compares the signal representative of the demand on the system with the signal representative of the actual position of the valve (feedback signal) and, if these signals differ by more than the adjustable "deadband", a signal to raise (further open) the valve or a signal to lower (further close) the valve is produced at a respective one or two outputs of the pulse position function generator 14.

The output of the pulse position function generator 14 associated with raising (further opening) the valve is connected to inputs B of LAND gates 16 and 18 and to an input A of an OR gate 20. An output of the AND gate 16 is connected to an input of a pulse generator 22 which establishes a minimum "on" duration of the raise (further open) output. The pulse generator 22 is connected to an input B of the OR gate 20. An output of the OR gate 20 is connected to an input C of an AND gate 24. An output of the AND gate 18 is connected to an input of a pulse generator 26 which has an output connected to an input of a NOT gate 28. An output of the NOT gate 28 is connected to an input B of the AND gate 24.

The output of the pulse position function generator 14 associated with lowering (further closing) the valve is connected to inputs B of AND gates 30 and 32 and to an input B of an OR gate 34. An output of the AND gate 30 is connected to an input of a pulse generator 36 which establishes a minimum "on" duration of the lower (further closing) output. The pulse generator 36 is connected to an input A of the OR gate 34. An output of the OR gate is connected to an input of an AND gate 38. An output of the AND gate 32 is connected to an input of a pulse generator 40 which has an output connected to an input of a NOT gate 42. An output of the NOT gate 42 is connected to an input C of the AND gate 38. An output of the AND gate 38 is connected to an input A of an OR gate 44 which has a run back signal applied to an input B thereof. This run back signal is also applied to an input of a NOT gate 46 which has an output connected to an input D of the AND gate 24. An output of the OR gate 44 is connected to the motor (not shown) and controls the lowering (further closing) of the valve associated therewith. Similarly, an output of the AND gate 24 is applied to the motor and controls the raising (further opening) of the valve associated therewith.

The output of the OR gate 44 is also connected to inputs A of an OR gate 48 and of an AND gate 50. Similarly, the output of the AND gat 24 is connected to inputs B of the OR gate 48 and of an AND gate 52. An output of the OR gate 48 is connected to an input of a NOT gate 54 which has an output connected to an input A of an AND gate 56. An output of the AND gate 56 is connected to an input of a pulse generator 58 which has an output connected to an input of a NOT gate 60. An output of the NOT gate 60 is connected to inputs A of the AND gates 16, 30, 24 and 38.

The outputs of the pulse generators 26 and 40 are also connected to raise and lower inputs, respectively, of a set/reset memory 62 which has a raise output connected to an input B of the AND gate 50 and to an input A of the AND gate 32 and a lower output connected to inputs A of the AND gates 52 and 18. An output of the AND gate 50 is connected to an input of a pulse generator 64 which has an output connected to an input of an analog transfer function generator 66. An output of the AND gate 52 is connected to an input of a pulse generator 68 which has an output connect d to an input of an analog transfer function generator 70. Outputs of the analog transfer function generators 66 and 70 are connected to inputs of a summation function generator 72 which has an output connected to an input of the summation function generator 12.

The signal representative of the actual position of the valve (feedback signal) is also applied to an input of a differentiation function generator 74 which has an output connected to an input of a high/low function generator 76. Outputs of th function generator 76 are applied to inputs of an OR gate 78 which has an output connected to an input B of the AND gate 56.

Operationally, if the signal representative of the actual demand on the system exceeds the signal representative of the actual position of the valve by more than the adjustable "deadband", a digital 1 is produced by the pulse position function generator 14 at its "raise" output. This digital 1 is applied to the inputs B of the AND gates 16 and 18 and the input A of the OR gate 20. In addition, if the valve has not moved within a predetermined period of time, as established by the duration of the pulse produced by the pulse generator 58, a digital 1 is applied to the inputs A of the AND gates 16 and 24. Such a predetermined period of time for the duration of the pulse produced by the pulse generator 58 could be approximately two seconds. The application of signals to the inputs A and B of the AND gate 16 causes it to conduct, resulting in actuation of the pulse generator 22. Typically, the pulse generator 22 produces a pulse of minimum duration such as 0.5 seconds resulting in a pulse of at least that duration being applied to the input C of

the AND gate 24 via the OR gate 20. In addition, if the valve last moved in the lower (further close) direction, a digital 1 is applied to th input A of the AND gate 18, resulting in the pulse generator 26 producing a pulse for a predetermined period of time, such as two seconds. Thus, a digital 1 will not be received by the input B of the AND gate 24 until after the pulse produced by the pulse generator 26 has terminated. If more than two seconds have elapsed since the last movement of the valve, and if the last movement of the valve was in the lower (further close) direction and more than two seconds have elapsed since the pulse position function generator 14 has produced a digital 1 at its "raise" output, then the AND gate 24 is allowed to conduct, resulting in actuation of the motor and raising (further opening) of the valve associated therewith. The conduction of the AND gate 24 causes a digital 1 to be applied to the inputs B of the OR gate 48 and the AND gate 52. If the last movement of the valve was in the lower (further close) direction, conduction by the AND gate 24 results in conduction by the AND gate 52 causing the pulse generator 68 to produce a pulse of predetermined duration, such as one second. This one second pulse causes a +1 to be selected by the analog transfer function generator 70 and this additional value is added to the demand via the summation function blocks 72 and 12 to compensate for gearing "backlash" resulting from the motor being caused to rotate in the opposite direction.

Conversely, if the signal representative of system demand is less than the signal representative of the actual position of the valve (feedback signal) by more than the "deadband", a digital 1 is produced at the "lower" output of the pulse position function generator 14. This digital 1 is applied to the inputs B of the AND gates 30 and 32 and to the input B of the OR gate 34. If the pulse produced by the pulse generator 58 has elapsed, a digital 1 is applied to the inputs A of the AND gates 30 and 38. The application of both inputs to the AND gate 30 causes it to conduct, resulting in the pulse generator 36 producing a minimum pulse, e.g., 0.5 seconds, to the input B of the AND gate 38. In addition, if the valve last moved in the raise (further open) direction, a digital 1 is applied to the input A of the AND gate 32, causing it to conduct and resulting in the pulse generator 40 producing a pulse having a predetermined duration, such as two seconds. Thus, a digital 1 will not be received at the input C of the AND gate 38 until after the pulse produced by the pulse generator 40 has terminated. If more than two seconds have elapsed sinc the last movement of the valve, and if the last movement of the valve was in the raise (further open) direction and more than two seconds have elapsed since the pulse position function generator 14 has produced a digital 1 at its "lower" output, then the AND gate 38 is allowed to conduct, resulting in conduction of the OR gate 44 which in turn results in actuation of the motor and lowering (further closing) of the valv associated therewith. The conduction of the OR gate 44 causes a digital 1 to be applied to the inputs A of the OR gate 48 and the AND gate 50. If the last movement of the valve was in the raise (further open) direction, then AND gate 50 conducts, causing the pulse generator 64 to produce a pulse having a predetermined length, such as one second. This one second pulse causes a -1 to be selected by the analog transf r function generator 66 and this additional value is added to the demand by the summation function generators 72 and 12 to overcome the gearing "backlash" resulting from the motor being required to rotate in the opposite direction.

From the foregoing it will be apparent that the pulse generators 22 and 36 establish the minimum duration of the motor run pulse. The pulse generators 26 and 40 establish the minimum "off" time between motor reversals--running up to running down and vice versa. The pulse generators 64 and 68 establish the additional running time for overcoming "backlash" by adding a value to the demand in the summation function generator 12 which results in a longer "on" time of the pulse position function generator 14. It should b noted that the pulse position function generator 14 does not operate continuously but only once every cycle time. The calculated "on" time, if shorter than the cycle time, will cause the motor to run and then stop. A calculated "on" time longer than the cycle time will cause the motor to run into the next cycle time in which a new "on" time will be calculated.

As previously stated, the signal representative of the actual position of the valve (feedback signal) is also applied to the differentiation function generator 74 which computes the rate of change of this signal. The computer rate of change is then applied to the high/low function generator 76 which produces an output signal if the rate of change is increasing faster than a first predetermined rate of change or is decreased more rapidly than a second predetermined rate of change. This output signal causes the OR gate 78 and the AND gate 56 to conduct, resulting in actuation of the pulse generator 58. The actuation of the pulse generator 58, in turn, causes the NOT gate 60 to apply to digital 0 to the inputs A or the AND gates 24 and 38, causes these gates to cease conducting. If the valve is moving, as determined by the OR gate 78, and no output pulse is being generated, as determined by the OR gate 48 and the NOT gate 54, then the AND gate 56 will conduct, causing the pulse generator 58 to produce an output pulse. This condition occurs when an output (AND gate

24 or OR gate 44) is established (digital 1) and then goes to a digital 0. The motor actuation will cease, but its rotation will not immediately cease, resulting in the pulse generator 58 producing an output puls . This puls passes through the NOT gate 60, preventing conduction of the AND gates 24 and 38, thus preventing any further rotation of the motor for the time period set by the pulse generator 58. This action prevents too many pulses from being sent to the motor in too rapid succession, preventing overheating of the motor. The pulse generator 58 thus establishes a mandatory time delay between motor run pulses. The operation of the system 10 can be over-ridden by the application of a runback signal to the input B of the OR gate 44, thus permitting lowering (further closing) of the valve during an emergency condition.

In summary, if the difference between the signal representative of demand and the signal representative of the actual position of the valve is within the "deadband", no action is taken. If, however, the "deadband" is exceeded, and the valve has just moved, no action can be taken until a predetermined period of time, e.g. two seconds, has elapsed. If, however, the "deadband" has been exceeded and the valve has not moved within a predetermined period of time, e.g. two seconds, a run pulse is delivered to the motor which controls the valve. A minimum motor run pulse of approximately 0.5 seconds is always produced when a motor run pulse has been calculated and established. If the valve last moved in a direction opposite to that presently desired, the motor run pulse is extended to overcome gearing "backlash". If a command to run the motor exists at the time a new command is produced and the new command results in operating the motor in the same direction, the motor command will be continued without interruption so as to minimise the number of motor starts and to provide the fastest response possible. Conversely, if the new command results in operating the motor in the opposite direction, the existing command is immediately terminated and a time period, e.g. two seconds, is entered into before the new command is allowed to be established. This minimises overshoot of the required position of the valve and results in the fastest response time. Thus, the system 10 will effectively respond to all possible conditions.

Claims

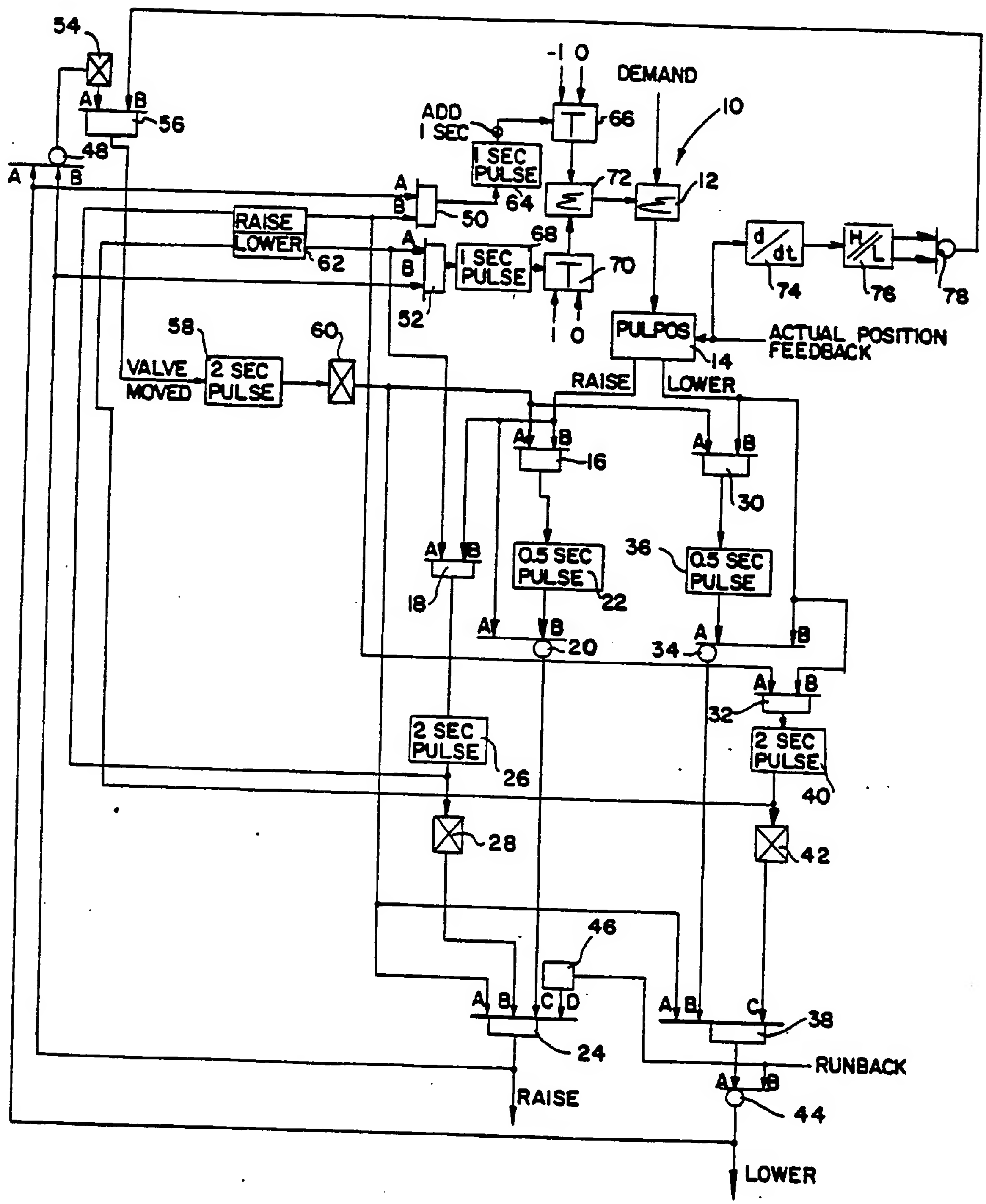
1. A control system for close positioning or modulating control of a positioning d vic , th system comprising comparing means (14) for comparing the actual position of the positioning device with a desired position of the positioning d vice, the comparing means (14) being operative to produce an output signal when the actual position of the positioning device differs from the desired position of the positioning device by more than a predetermined value, and means responsive to the output signal produced by the comparing means (14), said output signal responsive means being operative to cause the positioning device to move towards the desired position if a first predetermined period of time (58) has elapsed since the last movement of the positioning device and if a second predetermined period of time (26,40) has elapsed if the last movement of the positioning device was in a direction opposite to that of the desired position of the positioning device.

2. A control system according to claim 1, wherein said output signal responsive means includes means (52,68,70,50,64,66,72,12) for increasing the period of time the positioning device is actuated if the last movement of the positioning device was in a direction opposite to that of the desired position of the positioning device.

3. A control system according to claim 1 or claim 2, wherein said output signal responsiv means includes means (22,36) for actuating the positioning device for a minimum period of time, the minimum period actuating means (22,36) being operable upon the initiation of each output signal produced by the comparing means (14).

4. A control system according to claim 1, claim 2 or claim 3, including means (74,76,78,56) for determining movement of the positioning device after said output signal from the comparing means (14) has ceased, the movement determining means (74,76,78,56) being operative to prevent further movement of the positioning device until the first predetermined period of time (58) has elapsed.

5. A control system according to any on of the preceding claims, including means (44) for over-riding said output signal responsive means to permit closing of the positioning device.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RUNBACK
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RAISE
LOWER

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EUROPEAN SEARCH REPORT

Application Number

EP 87 30 8102

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	DE-B-1 908 606 (SULZER) * column 1, line 1 - column 2, line 53; column 4, line 18 - column 5, line 30; column 6, line 47 - column 7, line 22; claim 1; figure 1 * ---	1	G 05 D 3/16 G 05 B 11/18
A	US-A-4 591 773 (NUMATA) * abstract; column 2, line 37 - column 3, line 8; column 3, line 65 - column 5, line 2; claims 1-3; figures 1, 2 * ---	1	
A	US-A-4 335 341 (OGASAWARA) * column 1, line 5 - column 3, line 64; claims 1, 5, 6; figure 1 * -----	1,3	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 02 P
H 02 H
G 05 B
G 05 B
G 05 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	28-03-1988	BEITNER M.J.J.B.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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